When 1.550 G Of Liquid Hexane (c6h14) Combusts In A Bomb Calorimeter, The Temp Rises From 25.87oc To

When 1.550 G Of Liquid Hexane (C_6H_{14}) Combusts In A Bomb Calorimeter, The Temp Rises From 25.87°C To a certain temperature, it provides valuable insights into the energy released during hydrocarbon combustion. This process is fundamental in thermodynamics and calorimetry, helping chemists understand the energy content of fuels and their potential applications. In this article, we explore the details of this combustion reaction, the principles of bomb calorimetry, and how to calculate the heat of combustion based on temperature changes.

Understanding the Combustion of Hexane in a Bomb Calorimeter

What Is Hexane and Its Significance?

Hexane (C_6H_{14}) is a straight-chain alkane commonly used as a solvent and a model compound for studying hydrocarbon combustion. Its combustion reaction is a standard test for determining the energy content of fuels, which is crucial for energy management, engine design, and environmental considerations.

The Role of a Bomb Calorimeter

A bomb calorimeter is a sealed device used to measure the heat released or absorbed during chemical reactions, especially combustion. It operates under constant volume conditions, allowing precise measurement of the change in internal energy (ΔU) of the system.

Reaction Overview: Combustion of Hexane

The combustion of hexane can be summarized by the following balanced chemical equation:

C_6H_{14} (l) + 9.5 O_2 (g) → 6 CO_2 (g) + 7 H_2O (l)

This reaction releases a significant amount of energy as heat, which causes the temperature in the calorimeter to rise.

Calculating the Heat Released During Combustion

Given Data and Assumptions

To analyze the combustion process, the following data are assumed or provided:

- Mass of liquid hexane, $m = 1.550$ g
- Initial temperature, $T_{initial} = 25.87°C$
- Final temperature, T_{final} = ? (to be determined or given)
- Specific heat capacity of the calorimeter, $C_{calorimeter}$ = known constant
- Density and molar mass of hexane: $M_{hexane} \approx 86.18$ g/mol

Note: For this calculation, assume the final temperature post-reaction is known or measured. If not, the process involves using the temperature change to find the heat released.

Calculating the Temperature Change

The temperature change (ΔT) is:

$$\Delta T = T_{final} - T_{initial}$$

Once the final temperature is obtained from experimental data or measurements, ΔT can be used to find the heat released.

Heat Released (Q) Calculation

The heat released during combustion (Q) is related to the temperature change by:

$$Q = C_{total} \times \Delta T$$

where C_{total} is the total heat capacity of the calorimeter system, which includes the calorimeter's own heat capacity and the heat capacity of any additional components.

Alternatively, if the calorimeter's heat capacity is known, the calculation becomes straightforward:

- $Q = C_{calorimeter} \times \Delta T$

The value of Q represents the heat released by burning 1.550 g of hexane, which can be expressed in kilojoules (kJ).

Determining the Molar Enthalpy of Combustion of Hexane

Converting Mass to Moles

To find the molar heat of combustion ($\Delta H_{combustion}$), convert the given mass of hexane to moles:

$n = m / M_{hexane} = 1.550 \text{ g} / 86.18 \text{ g/mol} \approx 0.01798 \text{ mol}$

Calculating the Molar Heat of Combustion

The molar heat of combustion (ΔH) is then:

$\Delta H = Q / n$

Expressed in units of kJ/mol, this value indicates how much energy is released when one mole of hexane is burned.

Significance of the Temperature Rise in Calorimetry

Understanding the Data

The temperature rise from 25.87°C to the final temperature reflects the energy released. A larger ΔT indicates a more exothermic reaction, assuming constant heat capacity.

Applications in Energy and Environmental Fields

Accurate measurements of heat of combustion inform:

- Fuel efficiency calculations
- Environmental impact assessments
- Development of alternative fuels

Conclusion: The Importance of Precise Calorimetric

Data

Measuring the temperature change when liquid hexane combusts in a bomb calorimeter provides vital data for thermodynamic calculations. Understanding the relationship between mass, temperature change, and heat release enables chemists and engineers to evaluate fuel energy content, optimize combustion processes, and develop more sustainable energy solutions. Whether applied in research laboratories or industrial settings, these principles form the backbone of energy science and environmental stewardship.

Summary of Key Points

- Combustion of 1.550 g of liquid hexane releases a measurable amount of heat, raising the calorimeter's temperature.
- The temperature increase from 25.87°C to a higher temperature is directly related to the heat released.
- Calculating the molar heat of combustion involves converting mass to moles and dividing the total heat released.
- Accurate calorimetric measurements inform energy content assessments and fuel optimization.

Understanding these fundamental concepts helps in advancing energy technology and promoting sustainable practices in fuel usage.

Frequently Asked Questions

What is the significance of measuring the temperature rise when 1.550 g of liquid hexane combusts in a bomb calorimeter?

It allows determination of the heat released during combustion, which can be used to calculate the molar enthalpy of combustion of hexane.

How do you calculate the energy released from the temperature change in a bomb calorimeter?

By using the calorimeter's known heat capacity and the temperature increase, applying the formula $Q = C_{calorimeter} \times \Delta T$, where Q is heat transferred, $C_{calorimeter}$ is the calorimeter's heat capacity, and ΔT is the temperature change.

Why does the temperature in a bomb calorimeter increase during the combustion of hexane?

The combustion reaction releases energy in the form of heat, which raises the temperature of the calorimeter and its contents.

What additional information is needed to determine the molar enthalpy of combustion of hexane from this experiment?

The initial and final temperatures, the mass of hexane burned, and the calorimeter's heat capacity are needed to calculate the energy per mole of hexane combusted.

How can the molar mass of hexane (C6H14) be used in these calculations?

By converting the mass of hexane burned to moles using its molar mass (86.18 g/mol), you can determine the molar enthalpy of combustion from the total heat released.

What assumptions are typically made in calculating heats of combustion in bomb calorimetry?

Assumptions include complete combustion of the sample, no heat loss to surroundings, and that the calorimeter's heat capacity remains constant over the temperature range.

How does the temperature change upon combustion relate to the enthalpy change of the reaction?

The temperature increase reflects the exothermic nature of the combustion reaction; the larger the temperature change, the greater the heat released, allowing calculation of the enthalpy change.

What safety precautions are necessary when performing combustion experiments with liquid hexane in a bomb calorimeter?

Proper handling to prevent spills, working in a well-ventilated area or fume hood, avoiding open flames, and using appropriate personal protective equipment are essential due to hexane's flammability and volatility.

Additional Resources

Hexane Combustion: Unlocking the Energy Content of a Liquid Hydrocarbon

When analyzing the energy potential of hydrocarbons, the combustion of liquid hexane (C_6H_{14}) stands out as a fundamental process, especially in the context of calorimetry, where precise measurement of heat release offers critical insights into chemical energy storage. In this detailed exploration, we examine what happens when 1.550 grams of liquid hexane combusts within a bomb calorimeter, causing the temperature to rise from an initial 25.87°C. This case study not only underscores the principles of calorimetry but also highlights the importance of understanding the thermodynamics of hydrocarbon combustion.

Understanding the Context: What Is a Bomb Calorimeter?

A bomb calorimeter is a specialized device designed to measure the heat released or absorbed during chemical reactions, especially combustion reactions. It operates under constant volume conditions, meaning no work is done by expansion or compression of gases during the reaction. Its core components typically include:

- A sturdy, insulated container (the "bomb") that holds the reactants.
- An oxygen atmosphere to facilitate complete combustion.
- A thermometer or thermocouple to measure temperature changes.
- An ignition system to initiate the reaction.
- An external water bath or jacket surrounding the bomb to absorb and measure heat transfer.

In the scenario at hand, the combustion of liquid hexane occurs within this sealed environment, releasing energy that manifests as a rise in temperature. This temperature change is directly related to the heat of combustion, which can be calculated to understand the energy content of the hydrocarbon.

Initial Conditions and Reaction Details

Before delving into calculations, it’s essential to understand the initial parameters:

- Mass of hexane (C_6H_{14}): 1.550 grams
- Initial temperature (T_1): 25.87°C
- Final temperature (T_2): (to be determined based on the problem statement; placeholder for now)

The goal is to determine the heat released (Q) during the combustion and then use this information to calculate the molar enthalpy of combustion for hexane.

Thermochemical Foundations: Combustion of Hexane

Hexane is a straight-chain alkane with the chemical formula C_6H_{14}. Its combustion reaction, in the presence of excess oxygen, proceeds as:

$$ \text{C}_6\text{H}_{14} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \quad (\text{balanced form}) $$

More precisely:

$$ 2\, \text{C}_6\text{H}_{14} + 19\, \text{O}_2 \rightarrow 12\, \text{CO}_2 + 14\, \text{H}_2\text{O} $$

This reaction releases a significant amount of energy, which is a characteristic of hydrocarbon combustion—making hexane a useful reference fuel.

Calculating the Moles of Hexane Reacted

The first step involves converting the mass of hexane to moles:

$$
\text{Molar mass of C}_6\text{H}_{14} = (6 \times 12.01) + (14 \times 1.008) = 72.06 + 14.112 = 86.172\, \text{g/mol}
$$

Number of moles:

$$
n = \frac{1.550\, \text{g}}{86.172\, \text{g/mol}} \approx 0.01799\, \text{mol}
$$

This value is crucial for determining the energy per mole based on the temperature change observed.

Determining the Heat of Combustion from Temperature Rise

The core principle of calorimetry is the relationship:

$$
Q = C_\text{cal} \times \Delta T
$$

Where:

- Q = heat released during the reaction

- C_cal = heat capacity of the calorimeter (depends on its construction)
- $\Delta T = T_2 - T_1$ = temperature change during the reaction

Key considerations:

- The temperature change is directly proportional to the heat released.
- The calorimeter's heat capacity must be known or measured beforehand to convert temperature change into energy.

Suppose, for illustration, the temperature rises from 25.87°C to 31.87°C (a 6°C increase). If the calorimeter's heat capacity is known, say, 10,000 J/°C, then:

$$
Q = 10,000\, \text{J/°C} \times 6\, \text{°C} = 60,000\, \text{J}
$$

This total heat corresponds to the combustion of 0.01799 mol of hexane, allowing us to calculate the molar enthalpy of combustion.

Calculating the Enthalpy of Combustion per Mole of Hexane

Using the example:

$$
\Delta H_\text{combustion} = \frac{Q}{n} = \frac{60,000\, \text{J}}{0.01799\, \text{mol}} \approx 3,330,150\, \text{J/mol}
$$

Expressed in kilojoules per mole:

$$
\approx 3330\, \text{kJ/mol}
$$

This value aligns well with literature values, which typically report the standard enthalpy of combustion for hexane around −4163 kJ/mol under standard conditions, indicating that the actual temperature rise and calorimeter specifics influence the measured value.

Factors Influencing the Measurement

Several factors can affect the accuracy and interpretation of such calorimetric data:

- Calorimeter Calibration: Precise determination of the heat capacity is essential.
- Reaction Completeness: Ensuring complete combustion within the bomb.
- Heat Losses: Minimizing heat exchange with surroundings.
- Sample Purity: Impurities can alter the reaction's heat release.
- Temperature Measurement Precision: Accurate thermometry ensures reliable data.

Understanding these factors enables better calibration, more precise measurements, and trustworthy conclusions.

Implications and Applications of the Data

The combustion enthalpy of hexane is not merely an academic value; it underpins numerous practical applications:

- Fuel Efficiency: Knowing the energy content helps optimize fuel formulations.
- Environmental Impact: Combustion data informs emissions and environmental assessments.
- Thermochemical Databases: Adds to the body of knowledge for chemical engineering and research.
- Educational Demonstrations: Visualizes principles of thermodynamics and calorimetry.

Conclusion: Connecting Data to Broader Contexts

The combustion of 1.550 grams of liquid hexane within a bomb calorimeter, resulting in an observable temperature increase from 25.87°C, exemplifies the intersection of thermochemistry and practical measurement. Through meticulous calculations—converting mass to moles, relating temperature change to heat absorbed, and deriving molar enthalpy—scientists can gauge the energy potential of hydrocarbons. This process not only reinforces fundamental principles of calorimetry but also provides insights critical to energy science, environmental considerations, and chemical engineering.

In essence, the seemingly straightforward act of burning a small sample of hexane in a controlled environment encapsulates the complex interplay of chemical reactions, thermodynamic principles, and measurement science. As research advances and calorimetry techniques become more refined, our understanding of such processes continues to deepen, driving innovation and sustainability in energy utilization.

Note: Actual temperature data (final temperature) and calorimeter specifics are necessary for precise calculations. The values presented serve illustrative purposes to demonstrate the process and underlying principles.

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